"Fast-Response, Load-Matching Hybrid Fuel Cell"

Presented by:

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Project Information

Fast-Response, Load-Matching Hybrid Fuel Cell

Subcontract No. NAD-1-30605-15,
Awarded March 29, 2001

Awarded Under: NREL/DOE Distributed Power System Integration Research and Development Letter of Interest (LOI) Competitive Solicitation

NREL Technical Monitor: Tom Basso

Principle Investigators: Tom Key and Tom Geist,
EPRI PEAC Corp.

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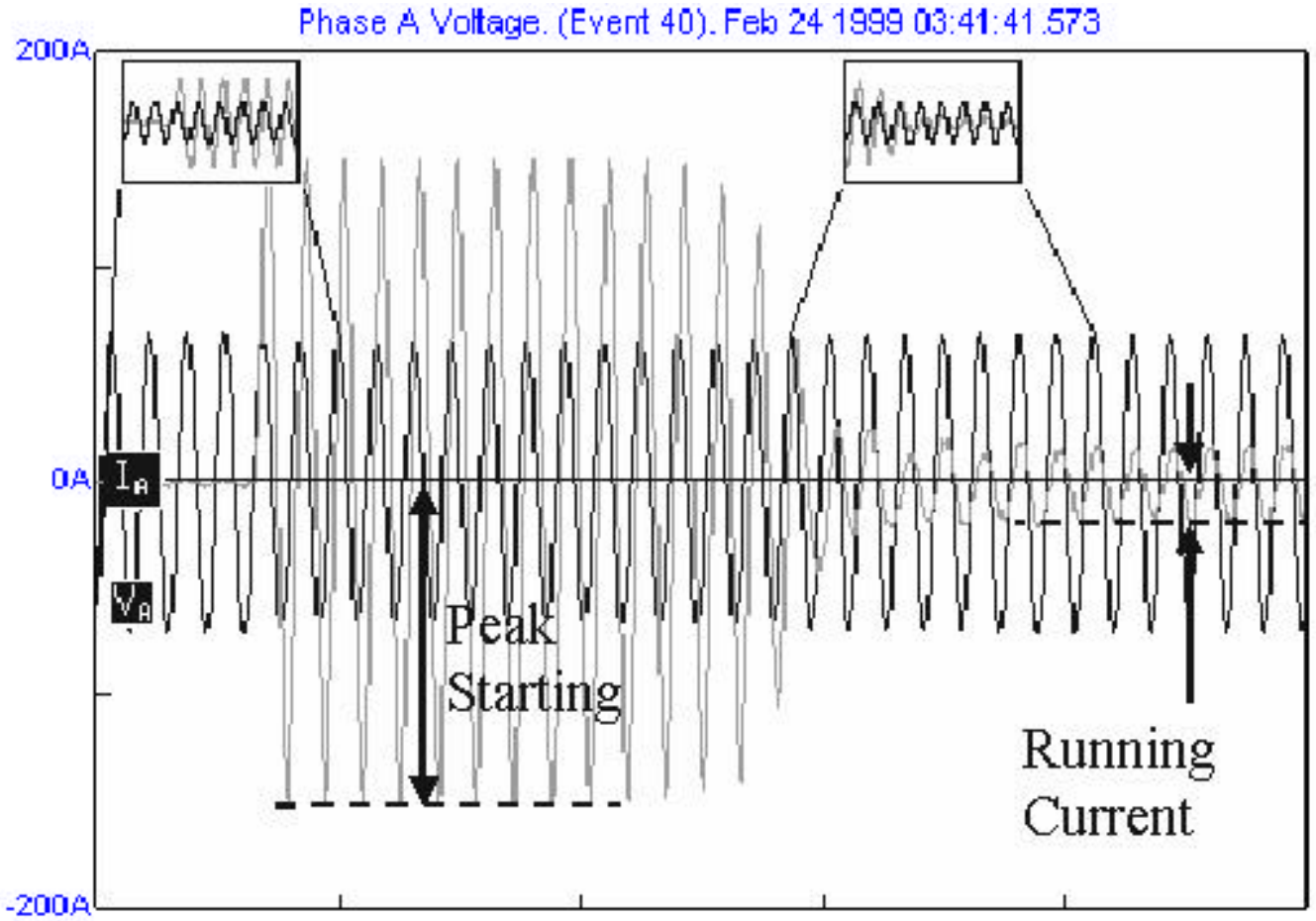
Project Perspective

- **Objective** – Demonstrate the potential of hybrid DER technology with improved compatibility and performance characteristics.
- **Opportunity** – Most environmentally preferred advanced generators, e.g. PV, FC, Wind and ?-Turbines, do not provide the robust source characteristics expected in power system design.
- **Scope** – Design, assembly, system test and analysis of hybrid PEM fuel cell with high-power high-energy storage capacitors.

Additional Capacity Required for Starting Appliances



- ***Inrush Current and Effect on Service Voltage for Starting a Residential Heat Pump.***
- ***Monitoring shows peaks are 6-8 times average power draw.***

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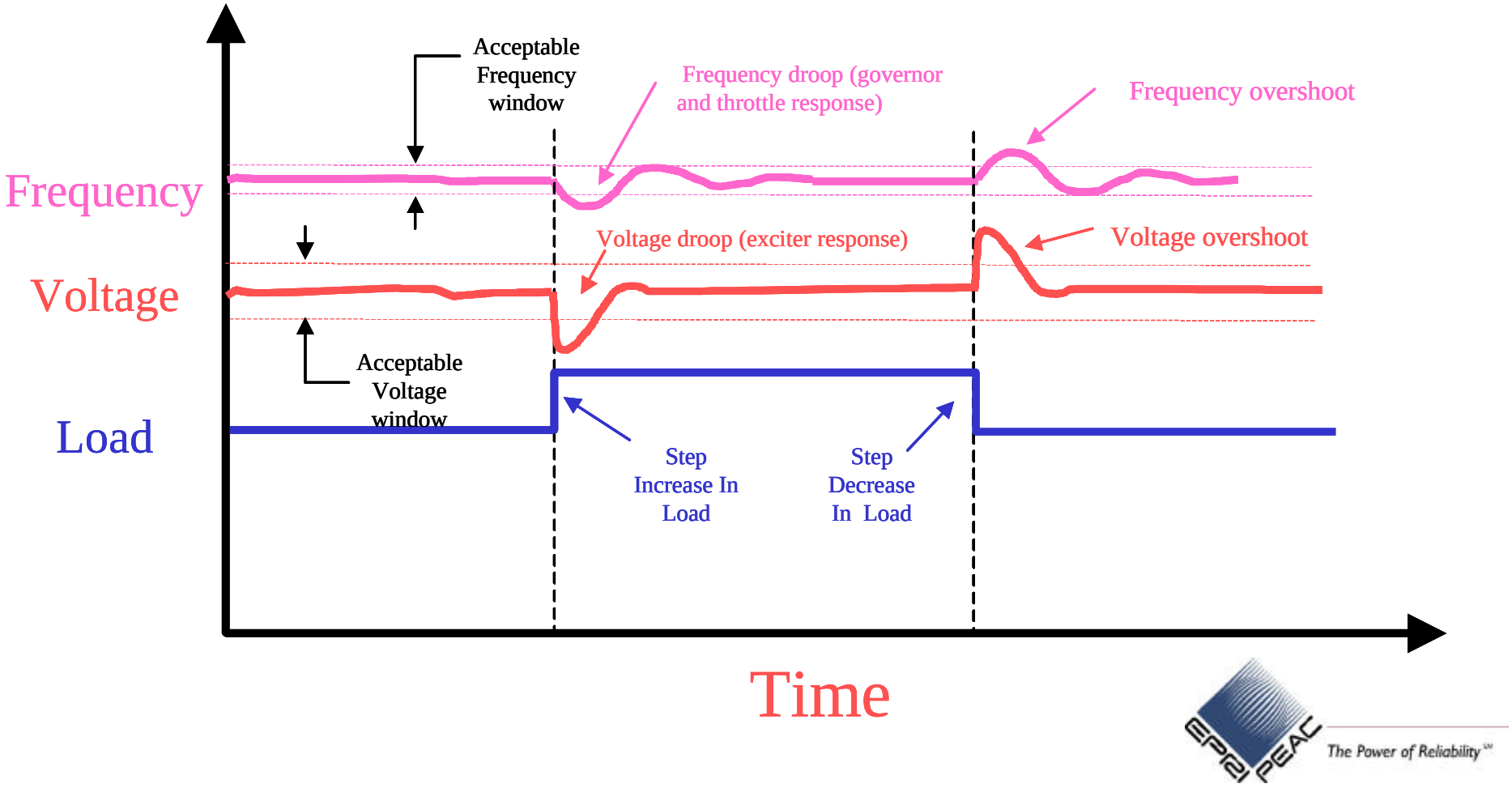
Effect of relatively large load change on DER power system



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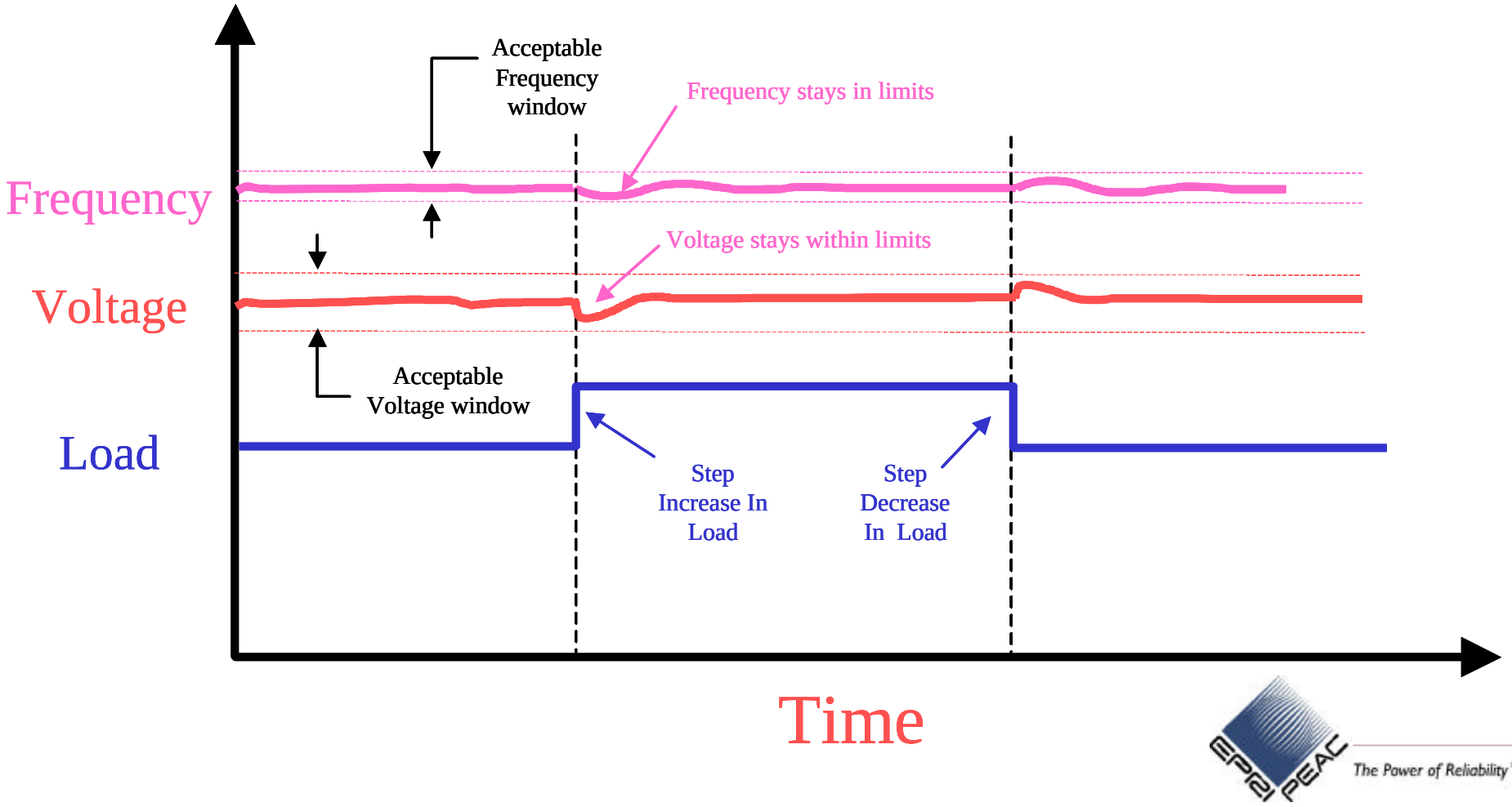
Potential system value of storage-stabilized DER power system



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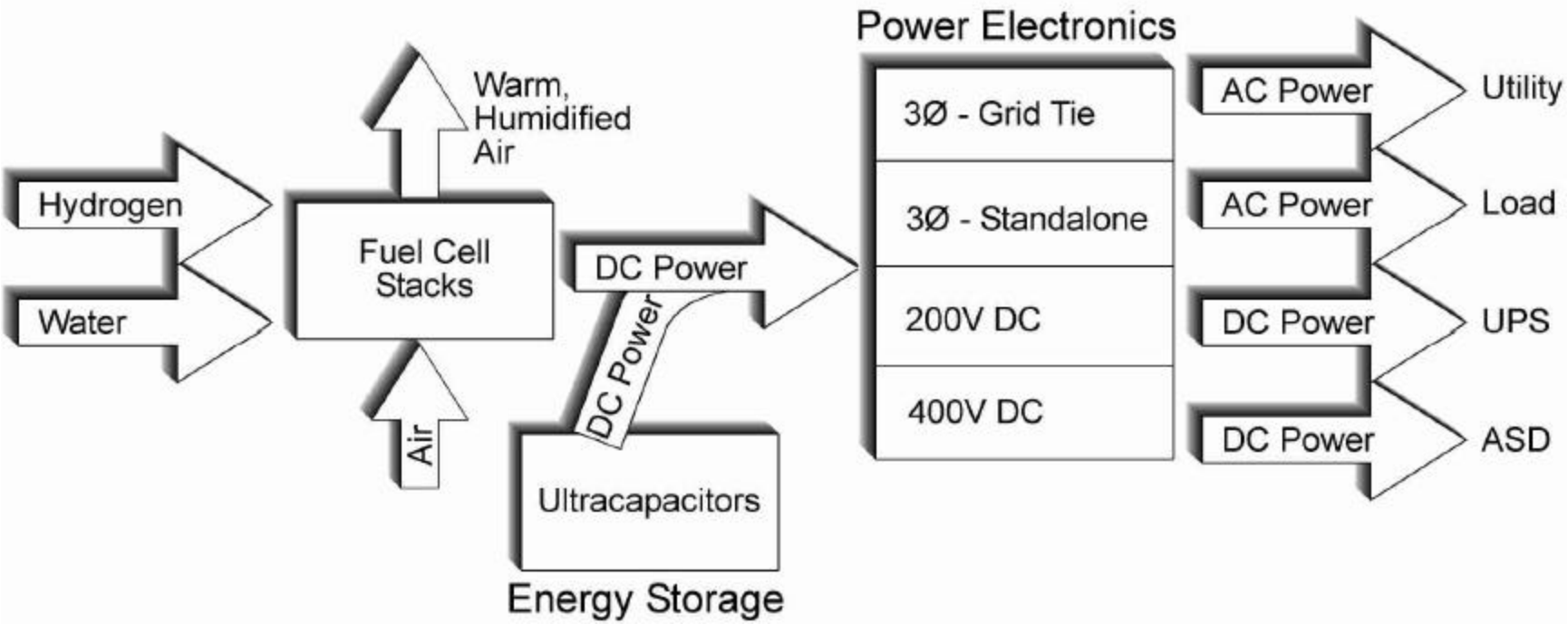
Project Significance

- Pulse load capacity problem of typical PEM fuel cell is solved by hybrid application of ultra capacitors
- Hybrid is also shown to provide value added power conditioning for grid and load transients
- Application economics are enhanced because a smaller fuel cell rating is capable of serving typical inrush and pulse loads

Configuration of Hybrid Fuel Cell/Ultra Capacitor DER System



- Fuel cell system designed for robust grid connection and response with potential improve load and grid support via ultra capacitors

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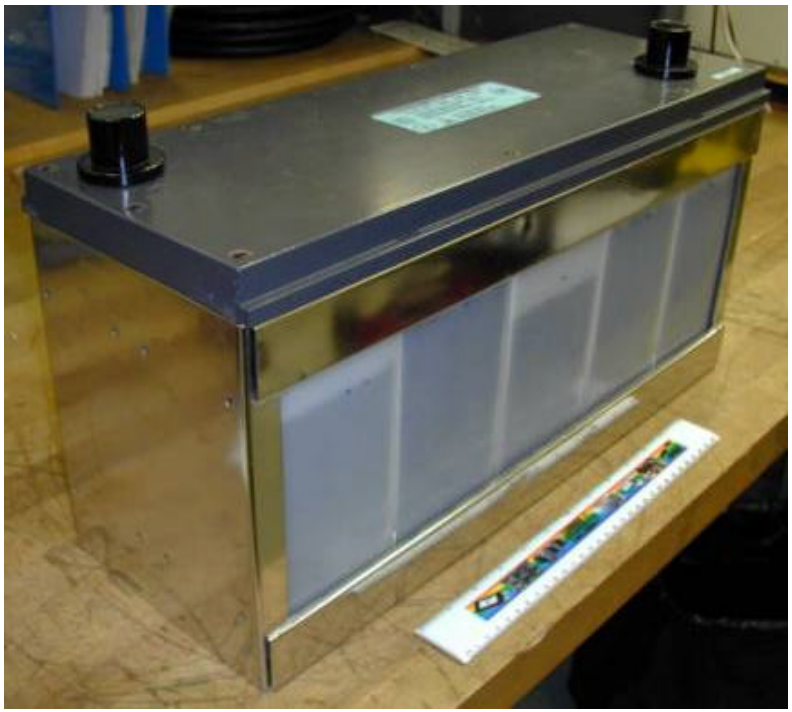
Three 16-V double-layer electrochemical ultra capacitors

- Higher-power, efficiency, and cycle life, faster recharging compared to lead-acid batteries more modular than flywheels.
- 20% - 30% of the energy in a typical auto battery



ESMA 8-16 V, 1 MJ, 34 kg

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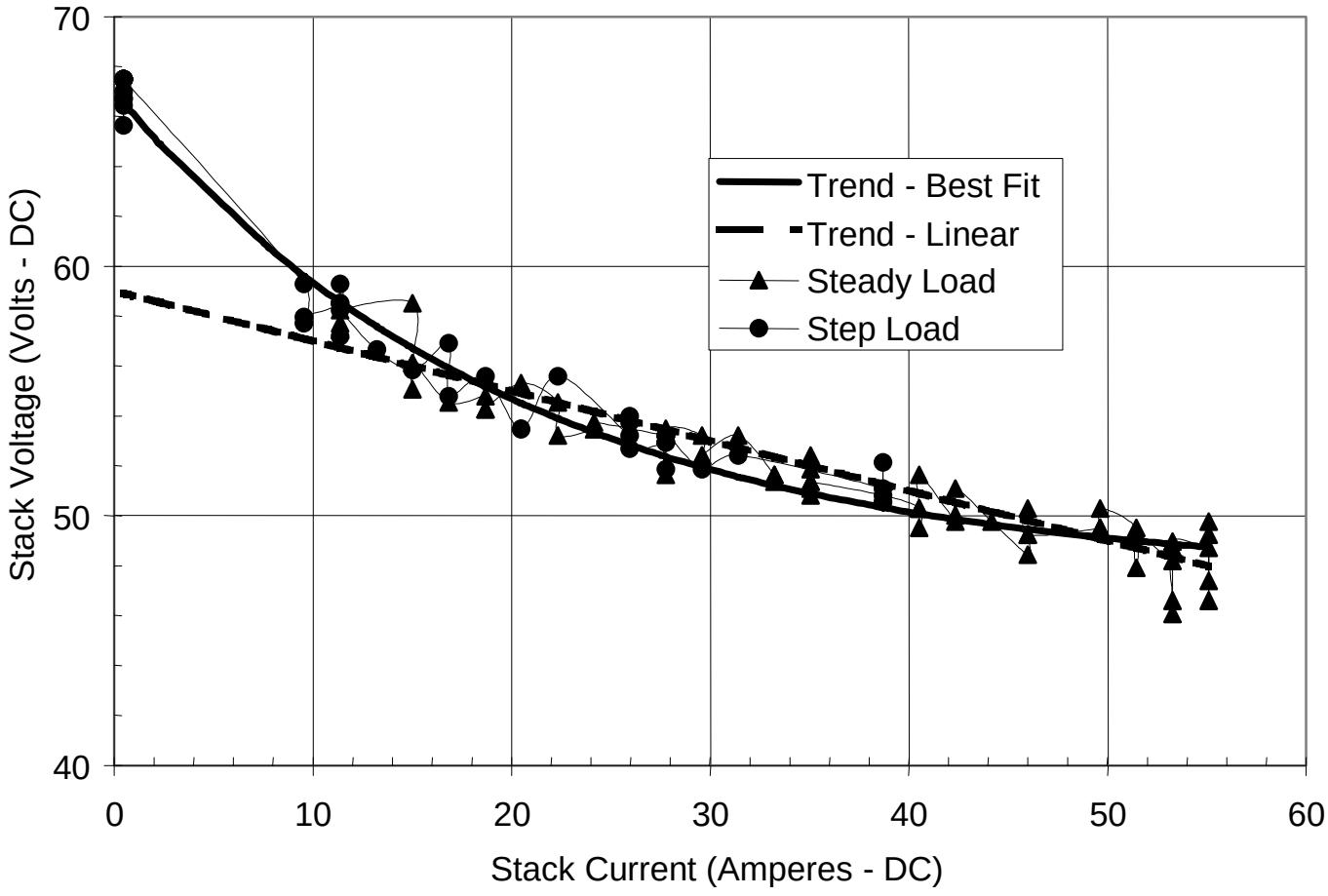
3-kW PEM Fuel Cell System

16-Vdc Ultra Capacitors in base of fuel cell cabinet

Fuel Cell System Test Set Up

Fuel cell V-I curve



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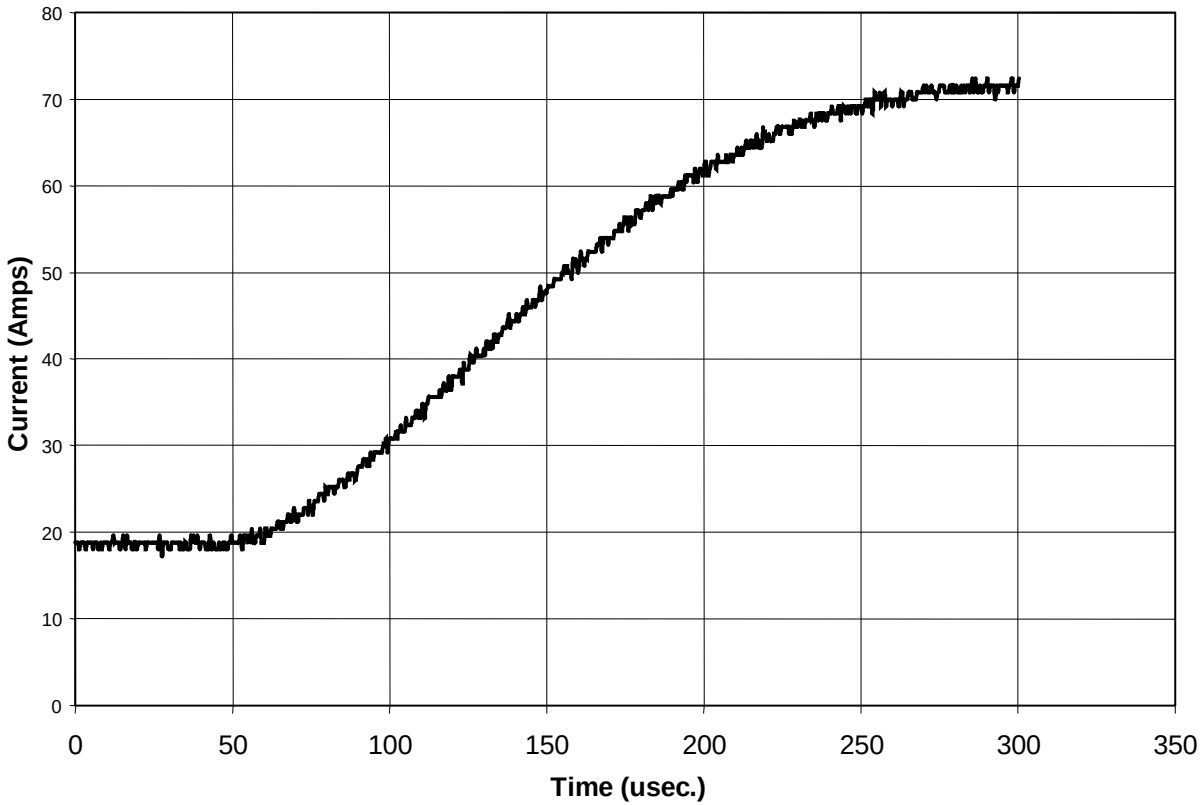
PEM Fuel Cell Step Load Response Measurement



- 20-70 amps at 50 volts (1000-3500W) in less than 250 ?sec.

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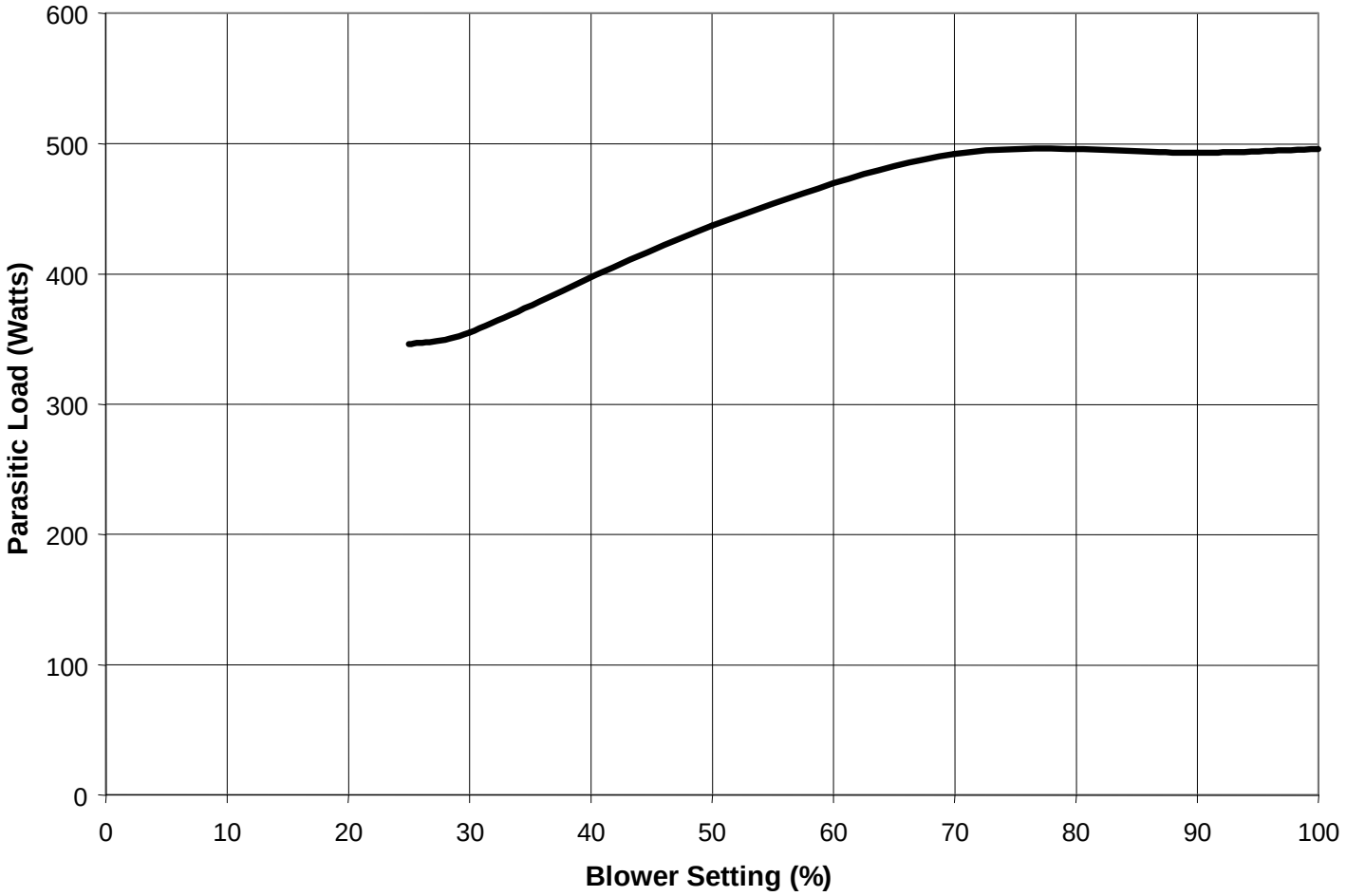
Reduction of fuel cell standby losses (operating at zero H_2)



During standby testing, the losses were reduced by varying the voltage to the air blower via digital control.

Stack failure occurred at 25% power draw

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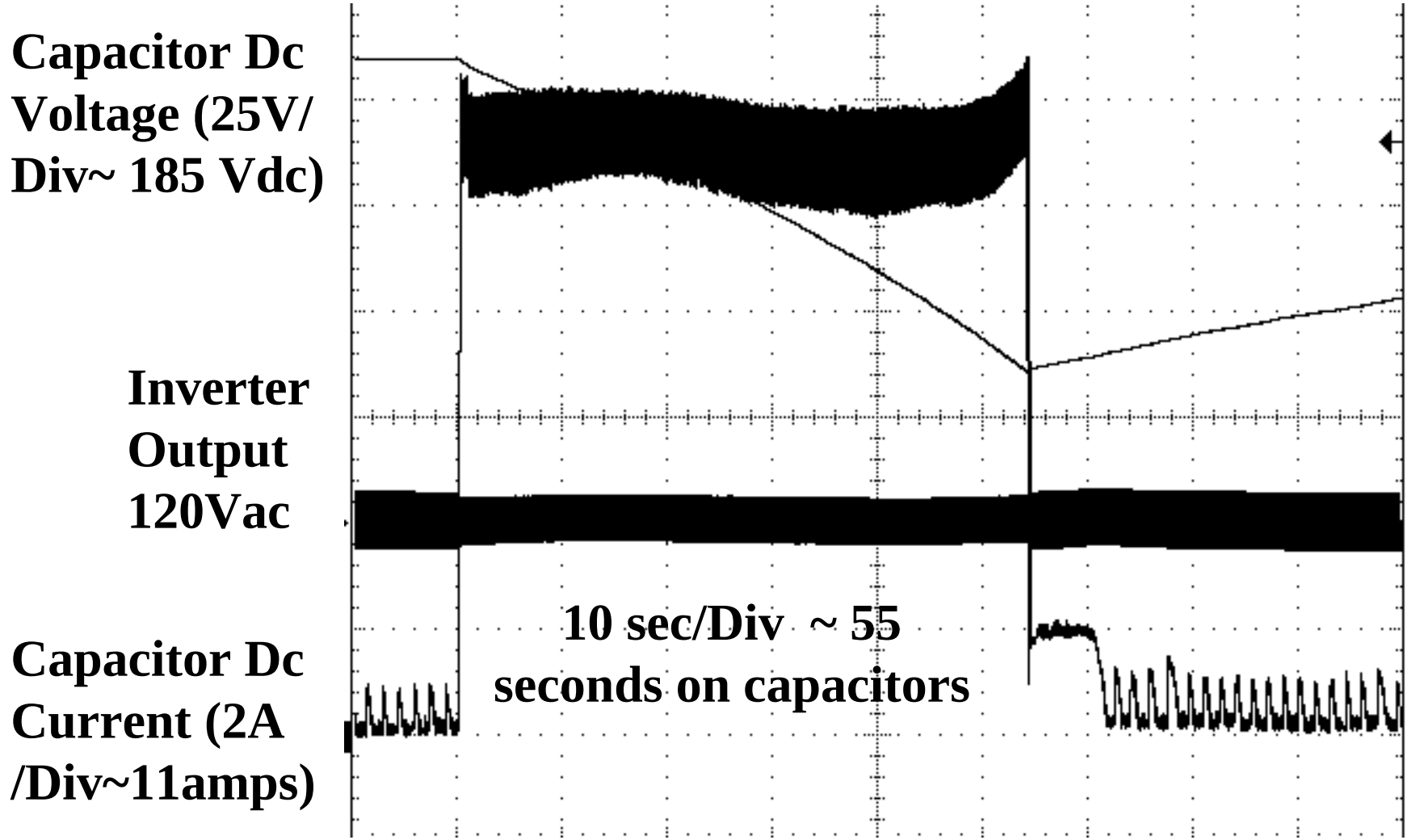
Ultra capacitor cycle tests simulating loss of fuel cell voltage



Note: No measurable change after 2000 ride-thru cycles

Progress and Schedule

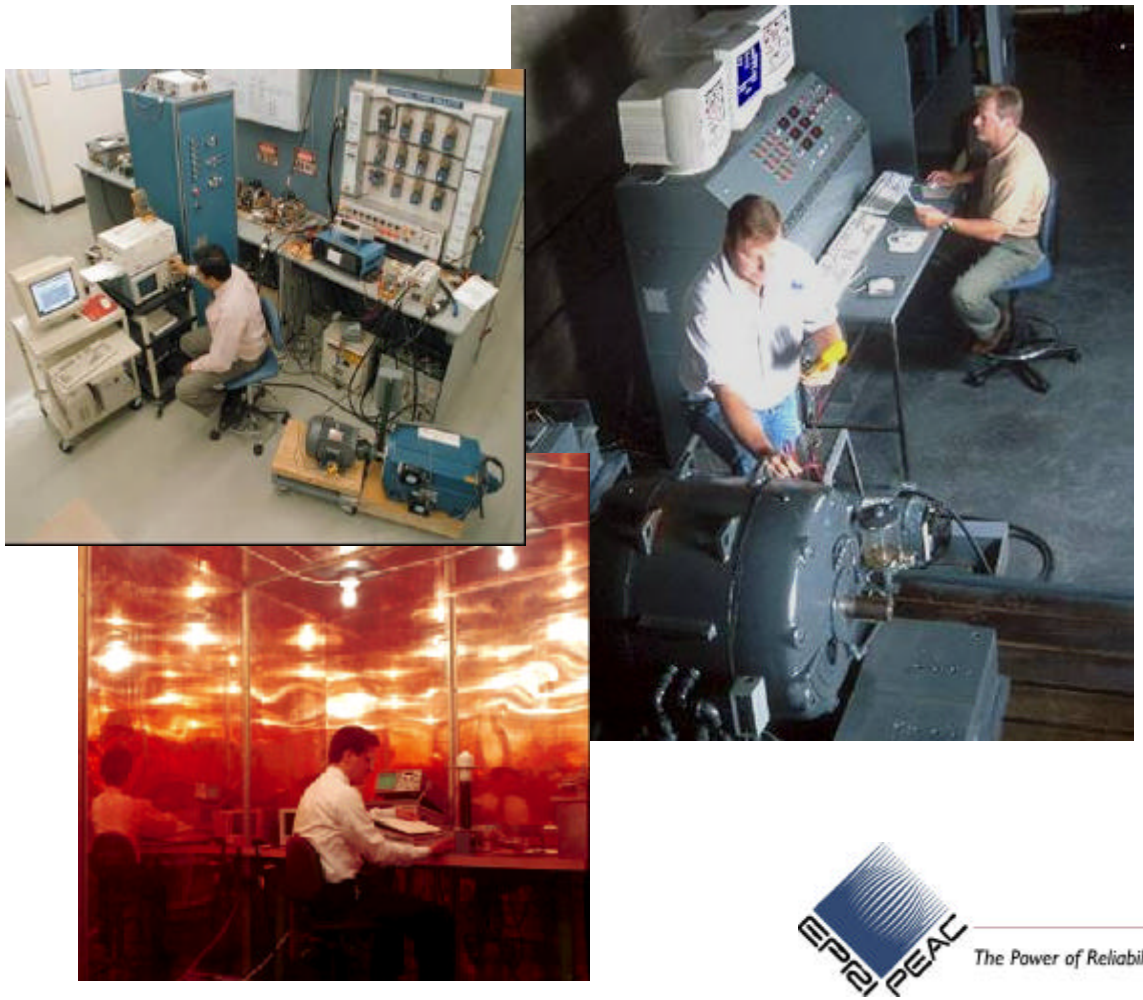
- Thru first 3 quarters completed separate evaluation of fuel cell and ultra capacitors
- Integrated ultra capacitors into fuel cell, demonstrated motor start capability
- 4th quarter will complete first year reports
- Year two, develop hybrid system test protocol and detailed evaluation
- Year three, add reformer module, more system tests, analysis and final report

Hybrid System Test Plans

- Evaluate hybrid under varying utility grid voltage conditions….
  - ANSI steady-state range, dynamic voltage sags and surges, harmonic distortion
- Evaluate hybrid with varying local loading
  - High inrush loads such as motor starting, step changes of linear and non-linear loads, transition from on-grid to off-grid operation
- Determine DER system energy performance in all operating modes

Motor and other End-Use Load Compatibility Test Facility

- Dynamic Performance Test Center
- Electro-Magnetic Compatibility
- Surge Test
- Power Conditioning lab



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DER System Test Facility
Knoxville, TN

Key personnel and experience

- Power System Design and System Integration
  - Tom Key and Gene Sitzlar, EPRI PEAC
  - Ben Banerjee, EPRI
- Fuel Cell System and Ultra Capacitors
  - Tom Geist EPRI PEAC and John Miller PhD, Consultant
  - Enable Fuel Cell
  - ESMA and Elit Ultra Capacitors
- System Performance Evaluation and Measurement
  - Rick Langley and Tom Cooke EPRI PEAC Lab